National Nuclear Security Administration

NNSA Livermore Site Office

Extending the Design Life of Mechanical Systems by Performing Optimal Preventative Maintenance

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Extending the Design Life

- Questions
- Comments – What have you experienced?
- Requirements
- Basic definitions
- Types of maintenance
- Maintenance optimization drivers
- Optimal preventative maintenance
- Life-cycle extension
- It's not just about having good PM's
- How does condition assessments factor in?

The research said…

- *Stewardship of Federal Facilities – A Proactive Strategy for Managing the Nation's Public Assets*, National Research Council (1998):
  - "Finding 1. ….the physical condition of the federal facilities portfolio continues to deteriorate, and many federal buildings require major repairs to bring them up to acceptable quality, health, and safety standards."
  - "Recommendation 1…..plan strategically for the maintenance and repair of its facilities in order to optimize available resources, maintain functionality and quality of federal facilities, and protect the public's investment……."
    - ✓"…by doing more PMs…at the right level"

So what?

- Have things changed?
- Are we doing enough PMs?
- Is it making a difference?
- *"…most convincing and compelling information is the future costs that can be avoided by undertaking early, preventative… maintenance activities." NRC*

Requirements

- DOE Order 430.1B *Real Property Asset Management*
  - CRD Section 5, "…must maintain real property assets in a manner that promotes operational safety, worker health, environmental compliance, property preservation and cost-effectiveness while meeting the program missions. This requires a balanced approach…."

Requirements Cont.

- *Energy Policy Act (EPAct)* of 2005
- DOE Order 433.1B *Maintenance Management Program for DOE Nuclear Facilities*
- Various Executive Orders
- Others have inherent requirements
  - *Code of Federal Regulations*

Key Terms Defined

- **Reliability**: the probability that an item will survive a given operating period, under specified operation condition without failure.
- **Failure**: when a system stops functioning as required or needed.
- **Mean Time to Failure**: time taken for a part or system to fail for the first time.
- **Mean Time Between Failure**: the predicted elapsed time between inherent failures of a system during operation.
- **Sustainment**: maintenance and repair activities necessary to keep the inventory of facilities in good working order. This includes regularly scheduled maintenance as well as anticipated major repairs or replacement of components that occur periodically over the expected serve life of facilities.

Types of Maintenance & Facts

- **<u>Reactive Maintenance</u>**: Run until it breaks.
- Advantages:
  - Low Cost
  - Less Staff

Reactive Maintenance Disadvantages

- When things finally break and they will….
  - Reduced lifespan or shortened life-cycle
  - Increased costs due to unplanned downtime
  - Increased labor costs – especially w/ overtime
  - Necessary replacement of equipment and other secondary components (e.g. not normally damaged) is often the result
  - Inefficient use of staff resources

Types of Maintenance & Facts Cont.

- **Preventative Maintenance (PM)**: Actions that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.
  - Based on specific time intervals – "Periodic Maintenance" based on manufacture's design criteria
  - Routine tasks to semi-complex tasks

PM Advantages

- Cost effective in capital intensive and high impact processes
- Flexible in adjustment of periodicity and tasks
- Increased component life-cycle / lifespan
- Increased reliability and availability – when needed it works like it is suppose to
  - Reduced failures or unplanned shutdowns
  - Less impact on the mission, budget is more level/stable
- Increased energy savings
- 12 to 18% increased savings over reactive maintenance

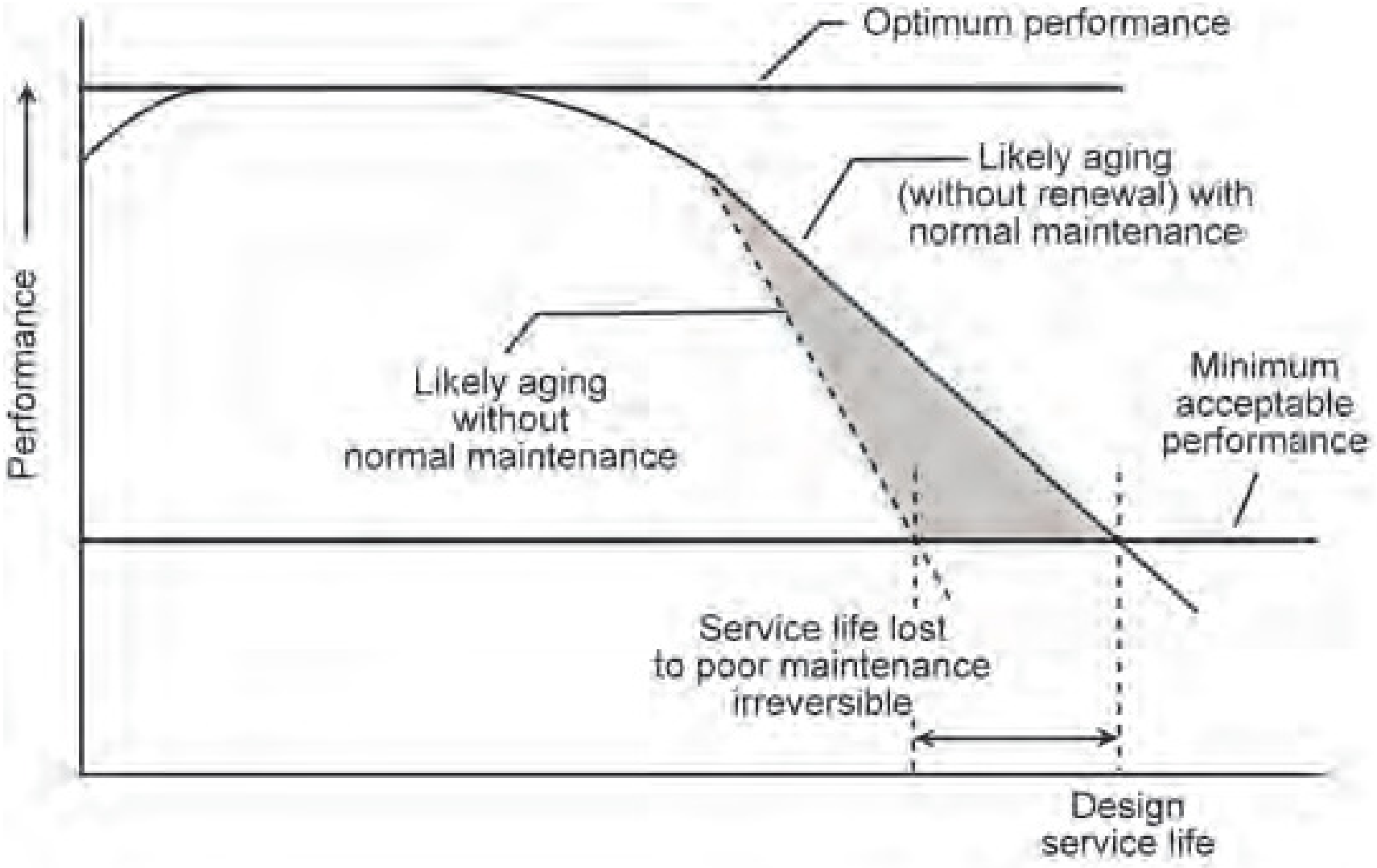
PM Disadvantages

- Labor intensive
- Performance of maintenance that is really not needed – too many of the same PMs
- Incidental damage through unneeded maintenance – “if it ain’t broke then don’t touch it”
- Equipment downtime can disrupt the mission/business
- Catastrophic failures still possible – it happens

Other PM Benefits

- Increased energy efficiency
  - 5 to 20% reduction of energy bills w/o significant capital investment
  - More likely to meet energy goals
- Increased safety
- Increased environmental compliance
- Increased employee health and morale
- Increased maintenance staff morale
- 10% increased employee productivity = 30% increase in bottom-line

Effect of Timely PMs



It's not just about PM's

- Optimum system performance and reliability also means must have:
  - Reliable staffing
    - Well trained
    - Enough at right levels, shifts, areas, and trades
    - Attitude = morale = increased efficiencies and better safety record
  - Well written PM procedures
  - Proper tools and equipment
  - Support staff

It's not just about PMs Cont.

- Good Computer Maintenance Management System (CMMS)
  - Master Equipment List
  - Data storage
    - Easily retrievable
    - Right information / data
  - User friendly
  - Interconnected and fully integrated with other systems
  - Warranty management
  - Etc., etc.

It's not just about PM's Cont.

- Drawings are available and accurate
- Lessons Learned Program is in place and adds value
- Stock inventory and parts storage is excellent
- Suspect Counterfeit Program works
- Work Planning & Control is in place, but is not cumbersome
  - Equipment status control
- Clear roles and responsibilities
- Morale / Attitude builders are in place
- Quality: measurements / metrics are taken in all areas and reacted upon – continuous improvement

Industry Benchmarks

- Equipment Availability >95%
  - World Class >98%
- Emergency Maintenance <10%
- Maintenance Overtime <5%
- PM Completion Rate >90%
  - World Class >98%
- World Class Ratio PMs vs. Reactive >60/<30%
  - Difference is Predictive and special maintenance

Cost Benefit Analyses

- When should you eliminate a PM or add a new PM?
  - **Simple payback**: ratio of total PM costs in first-year vs. ramification of unplanned downtime
    - Injury avoidance
    - Property or secondary damage
    - NOV avoidance
    - Loss of efficiencies in work and quality
    - Wasted time – labor and materials
    - Benefits are numerous and complicated
- **Value Engineering** (RPAM requirement)

Cost Benefit Analyses Cont.

- **<u>Life-cycle Costing</u>**: The present worth of all costs associated with an asset/system vs. the overall cost of performing the PMs over its lifespan.
  - Will investing in the PM work for an asset pay off in the end?
    - Quite complicated, but almost always, "Yes!"
    - Minimizing failures translates to maintenance and capital cost savings.
  - FEMP Life-Cycle Cost Training
    - http://www1.eere.energy.gov/femp/program/lifecycle.html

So what about CAS?

- Condition assessment surveys / inspections are not PMs but they:
  - Are another visual inspection
    - See
    - Smell
    - Feel
    - Listen
  - Work Order can be issued to address before catastrophic failure
  - Feedback and improvement: recommendations for adding PMs w/ specific tasks

Overhauls & Rebuilds

- Are not pure PMs
- Can be treated just like a PM:
  - Scheduled and entered into CMMS
    - So you don't forget
    - So you can plan
    - So you can budget
  - Follows a procedure similar to a PM
- CAS determines when to be scheduled
  - Inspector adjusts when it must be replaced
  - Cost estimates are made and budgeted

Design for Maintenance

- Design for conducting PMs
  - Maintainability
- Design for repairs and replacements too
- Key factors:
  - If it can't be reached then it doesn't get done.
  - Accessibility
    - Example: HVAC VAV – all moving parts in mechanical room
  - Visibility
  - Inspectability

Resources/References

- ***Operations & Maintenance Best Practices – A Guide to Achieving Operational Efficiency***
  - DOE Office of Energy Efficiency and Renewable Energy
    http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf
- ***Federal Energy Management Program (FEMP)***
  http://www1.eere.energy.gov/femp/
- ***Intelligent Sustainment and Renewal of DOE Facilities and Infrastructure***, National Research Council, National Academy Press, Washington D.C. 2004
- ***Stewardship of Federal Facilities***, National Research Council, National Academy Press, Washington D.C. 1998
- ***Managing the Facilities Portfolio – A Practical Approach to Institutional Facility Renewal and Deferred Maintenance***, Applied Management Engineering P.C. 1991
- ***Whole Building Design Guide***, National Institute of Building Sciences
  http://www.wbdg.org/resources